SANITARY LANDFILL
CONTROLLING WIND-BLOWN LITTER

Alberta
ENVIRONMENT

Waste Management Series
Publication No. 8

85-3756/

SANITARY LANDFILL

CONTROLLING WIND-BLOWN LITTER

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(1983)

ACKNOWLEDGEMENTS

My thanks go to Ed Oszcowsk, operator of the Crowsnest Pass, Pincher Creek Regional Sanitary Landfill, who inspired the writing of this report. His continuous experimentation in controlling wind-blown litter is invaluable. Many of the ideas presented in this report are based on his experience.

Also, appreciation is expressed to Roy Maplethorpe, operator of the Leduc Regional Sanitary Landfill, for explaining user control to prevent blowing papers, and for describing effects of whirlwinds and other wind effects.

There are numerous other people who were instrumental in providing information and reviewing the written text, but special thanks is expressed to Randy Angle and Jennifer McQuaid-Cook, both of Alberta Environment.

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INTRODUCTION

The problem of blowing litter can occur away from the landfill site or on the site. Off the site, the problem is credited to refuse blowing or dropping off of refuse transport vehicles. On the site, the cause is refuse blowing away during the dumping and landfilling operations. It is the on-site problem that is the prime concern of this report.

There are no surefire controls, short of building a dome over the landfill, that will completely stop refuse from blowing away. The landfill operator must be prepared and willing to pick up litter that "gets away". However, there are some basic principles and techniques, that, if properly used, can reduce the amount of blowing litter, and thus reduce the work required to pick it up.

In this report, an explanation is given of typical wind patterns a landfill operator may encounter. By understanding and taking advantage of wind patterns, the operator will succeed in reducing blowing litter.

In writing the report, it was assumed the reader has a good working knowledge of sanitary landfill operations. Thus, a description of landfill operation is not included.

CHAPTER 1

HOW REFUSE IS WIND-BLOWN

During the unloading and landfilling operations, refuse will be exposed to wind and is bound to be carried by it. The degree to which refuse will be transported depends upon the following factors:

1. Strength of wind
2. Strong turbulence
3. Compaction of refuse
4. Confinement of refuse
5. Moisture content of refuse
6. Type of Waste

Naturally, the stronger the wind, the greater the amount of refuse that will be blown about. Stronger winds will pick up larger objects and will carry refuse longer distances. For example, in a 10 mph (16 km/h) wind, a light piece of paper, such as an empty letter envelope, dropped from an unloading vehicle, can be carried 25 feet (7.6 m) before striking the ground. The same envelope can be carried 120 feet (37 m) before striking the ground in a 50 mph (80 km/h) wind. If the air is strongly turbulent, it can be carried even greater distances.

It only stands to reason that the heavier the object the less likely it is that it will to wind-blown. Conversely, the stronger the wind, the more likely the object will be moved. The following table lists objects

and the wind speed necessary to carry each object away from the working area upon dumping.

TABLE 1

Wind Speed and Wastes Blown*

10 to 15 mph. (16 to 24 km/h)	- envelope - dry slightly crumpled paper
15 to 20 mph. (24 to 32 km/h)	- empty plastic bags
20 to 30 mph. (32 to 48 km/h)	- flat sheets of corrugated cardboard - crumpled paper towel
30 to 40 mph. (48 to 62 km/h)	- plastic strips - empty facial tissue box - tightly crumpled paper
40 to 60 mph. (62 to 88 kmph)	- empty milk cartons - corrugated cardboard box
over 60 mph. (over 88 kmph)	- 6 oz. metal cans (170 cc)

* It is assumed that the object is dropped five feet (1.5 m) from an unloading vehicle and is carried 20 feet (6 m). The table is based on mathematical calculations. No field tests were conducted to prove the that information is correct.

The refuse items that are wind-blown are also carried along the ground surface until they are caught by a fixed object, whether it be grass, soil pile or a fence. If the ground surface is flat and there are no obstructions, the refuse can be carried considerable distances. It can also be said that the lighter the object, the farther and faster it will be carried.

Refuse that is compacted prior to dumping, (i.e. by a compacting collection truck) is less subject to blowing because light items are intermingled with heavier objects. Some wastes are also more likely to be higher in moisture content, making them heavier and more resistant to blowing.

If refuse is contained in boxes, plastic bags or other such containers, it is less likely to be blown about. However, if the container is broken by the landfill equipment, or by scavengers, its contents will be exposed to the wind.

Strong turbulence can be created at a landfill with winds blowing over and around stockpiles and fences. Such winds can be very frustrating unless control measures are used. The following chapters explain the wind patterns that can develop and corresponding control methods.

CHAPTER 2

WIND PATTERNS

"Landfill operators must learn to observe local wind patterns in detail in order to solve this day-to-day problem".*

Flow Patterns

If the operator watches wind patterns, he will soon see ways of taking advantage of the wind. Normally the wind moves along the ground in one direction. An obstruction to the air surface will change that pattern, either vertically or horizontally. If the obstruction is gentle, such as a small knoll, the wind flow will tend to follow the shape of the ground. If the obstruction creates a sharp change, strong turbulence is created. The extent of the turbulence depends upon the strength of the wind and the shape and size of the object.

Figure 1. Wind Effect with Ground Surface Knoll

* Bert Fowler "How to control blowing paper" Waste Age, Nov. 1982.

Figure 2. Wind Effect with Ground Surface Trough

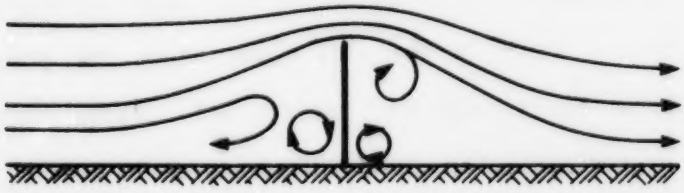

Figure 3. Wind Effect with Sharp Obstruction (ie. Solid Fence)*

Two obstructions set apart will funnel the air through the centre and increase wind speed. The following diagram shows this effect in a sanitary landfill trench.

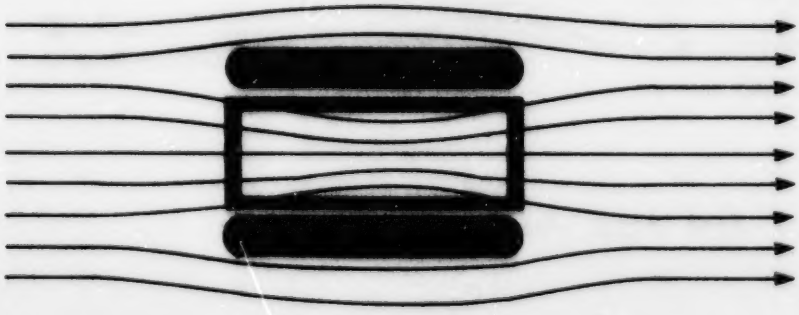

Figure 4. Funnelling Wind in a Landfill Trench*

* Note: Wind speed is indicated by line spacing, narrow spacing indicates higher wind speeds

Viewing the same trench from the side, air is displaced vertically. The vertical displacement tends to counteract the funneling effect on wind speed. Some tubulance can be created at the edges of the trench.

Figure 5. Vertical Wind Patterns in a Trench

If the same trench is subjected to a crosswind, strong turbulence can be created. To a landfill operator this means problems. Papers will be lifted and blown about the landfill. Papers that are carried upwards may be caught in the upper stream of air and carried off the property.

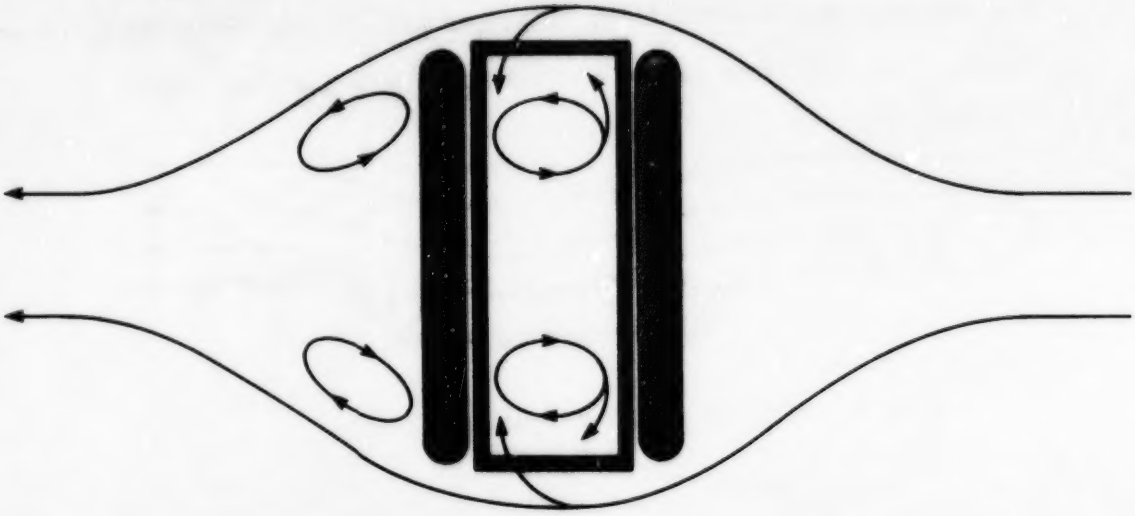

Figure 6. Crosswind Turbulence

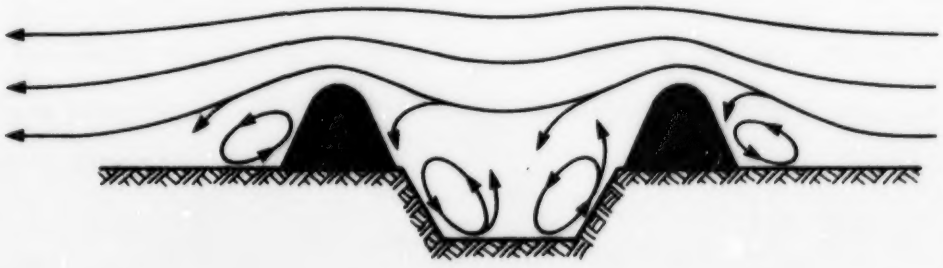

Figure 7. Updraft Forms with Crosswind

The landfill operator can see the effects of turbulence where pieces of paper appear to be floating up and down and around in circles. Some pieces travel in a circular path and drop to the ground from the bottom of the circle. Other pieces may follow the same path but exit the circle from

the top to be carried away by the mainstream of the wind. It is this upward movement of paper that increases the difficulty of controlling blowing litter.

A sanitary landfill may be subject to crosswinds, parallel winds or winds from oblique angles on any given day. The landfill operator must be prepared for such changes.

Whirlwinds

Whirlwinds can cause temporary havoc to litter control. They occur on hot summer days as a result of convection currents. They can also be created when wind drops over an embankment, such as a river valley. An example of this is the whirlwinds that occur at the Drumheller regional landfill, which is located in deep ravines of the Red Deer River Valley.

A whirlwind will pick up papers and loft them to great heights. If these winds are especially strong, even large cardboard boxes can be lofted. A whirlwind may carry objects for some distance before dropping them to the ground.

These winds may be common in hot weather, but do not pose extreme problems for the landfill operator. Even though an open landfill working face may be struck by a whirlwind, repetitive strikes are likely to be infrequent. Also, the volume of litter picked up in these winds is not very large.

If an operator is concerned about whirlwinds, it is suggested that he keep the open refuse face as small as possible. This will reduce the chance of a direct strike. If one does strike, the operator's only recourse is to pick up what litter he can find.

Climatic Patterns

Wind statistics are useful in determining the frequency of wind direction and wind speeds. Statistics that illustrate climatic wind patterns are available from Environment Canada.

TABLE 2

Pincher Creek 1973 - 1980

Direction	% Annual Frequency Speed mph (km/h)	Annual Mean Wind Speed mph (km/h)	Maximum Hourly Wind
N	1.5	5 (8)	-
NE	5.7	7 (11)	-
E	6.9	6 (10)	-
SE	6.5	6 (10)	-
S	3.2	6 (10)	-
SW	12.3	14 (23)	54 (83)
W	57.7	17 (27)	58 (87)
NW	6.0	9 (14)	-
Calm	0.2	-	-

TABLE 3

Edmonton, Stony Plain 1967 - 1980

Extracted From Canada Climatic Normals (1951 - 1980)
Environment Canada

Direction	Annual % Frequency	Annual Mean Speed mph (km/h)	Maximum Hourly Wind Speed mph (km/h)
N	6.1	6 (10)	-
NE	7.9	6 (10)	-
E	11.7	6 (10)	-
SE	13.1	7 (11)	-
S	6.5	5 (8)	-
SW	12.8	7 (11)	28 (95)
W	16.8	7 (11)	-
NW	24.7	9 (14)	36 (58)
Calm	0.4	-	-

In the southern regions of Alberta, strong winds may be expected from the west and southwest. In the central and northern regions, strong winds may come from the northwest and southwest. It is these strong winds which the designer of a landfill should take into consideration when planning a site.

CHAPTER 3

LANDFILL DESIGN AND OPERATION

The sanitary landfill designer must study wind patterns that affect the specific landfill site. Wind statistics indicate general wind patterns, but discussions with nearby residents and former property owners may reveal some local variation.

The designer must decide whether it is more important to catch paper on a downwind fence or to provide windbreaks. If the wind direction is varied, portable catchment fences may be required. If wind is constant in direction, windbreaks can be more useful (i.e. Chapters 4 & 5). This decision can be the basis for determining the direction and positioning of the landfill trenches.

Keep top of lift below level during windy periods
Do not unload solid waste from the top
WIND
• TECHNIQUE No. 1
Work solid waste cell " into wind"
Fencing required
Unload at bottom
• TECHNIQUE No. 2
Work trench perpendicular to wind
Fencing may not be required
Unload solid waste at bottom

Figure 8. Operating Techniques (Brunner, Keller E.P.A. 1972)

If the prevailing winds are strong, the second method may not be successful because of the turbulence created (see Chapter 2). If there is turbulence, the catchment fences will not work well. Strong prevailing winds can determine the catching of blowing refuse, thus the first method may be preferred.

As an alternative to these methods, a variation of method 2 can be applied. The soil stockpile is placed on the downwind side of the trench and a windbreak is constructed on the upwind side. (Chapter 5 discusses windbreaks in greater detail)

Figure 9. Windbreak Alternative

It is inevitable that landfilling operations will take place above the ground level as trenches are filled. There will be changes in the wind patterns as this occurs, and there may not be natural barriers to hide the disposal area behind. Once the land is filled above ground, the operator may have to resort to catchment fences as the only method of control. However, portable windbreaks upwind can also be used.

Operators of small sanitary landfills have suggested that equipment should not be operated to compact the refuse in high wind conditions. They place a light scattering of soil over the exposed refuse to hold it in place and wait for the wind to subside before compacting. This may be practical for landfills with daily waste volumes less than 50 tons, (100 tonnes) but larger landfills cannot operate this way. Compacting and covering the wastes as soon as possible is necessary in order to reduce the amount of blowing papers.

CHAPTER 4

CATCH FENCES

Catch fences are placed downwind from the working face to stop blowing refuse from escaping the site. Properly placed, catchment fences are invaluable. Improperly placed, they are worthless. The further the catchment fence is from the working face, the less effective it becomes. Winds can spread the papers over a wide area before reaching the fence, or updrafts can carry the paper over the fence.

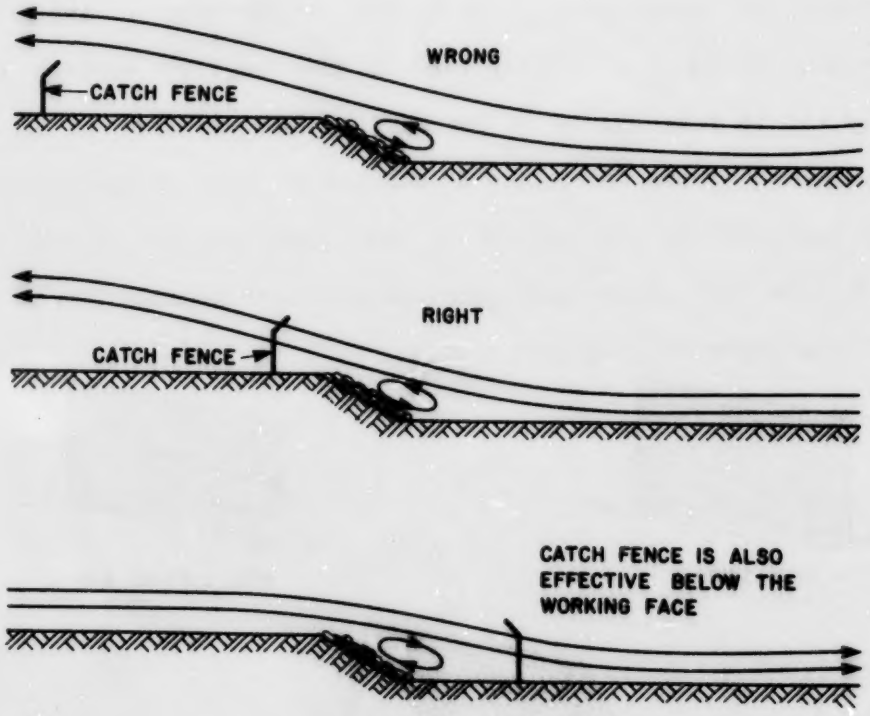

Figure 10. Placement of Catch Fence

It's often said that catch fences don't work. Common reasons for failure of catch fences are:

1. Not tall enough
2. Not positioned properly
3. Fences not moved with wind changes
4. Not maintained
5. Not enough fenced area.

Permanent fences surrounding the landfill site are valuable as a second line of defence to stop litter that escapes the working area and is blown along the ground surface. Such fences may be constructed of wire mesh, or may be natural vegetation or planted tree lines. Trees, shrubs and/or chain link fences are best located on the perimeter of the property.

Portable fences are normally used in the immediate working area so that they can be moved daily as the working face moves or in accordance wind changes. Portable fences can be mounted on skids and pulled with the landfill equipment or constructed so that they can be carried by the equipment. Two inch square mesh openings work best because they allow for free air flow while stopping most papers.

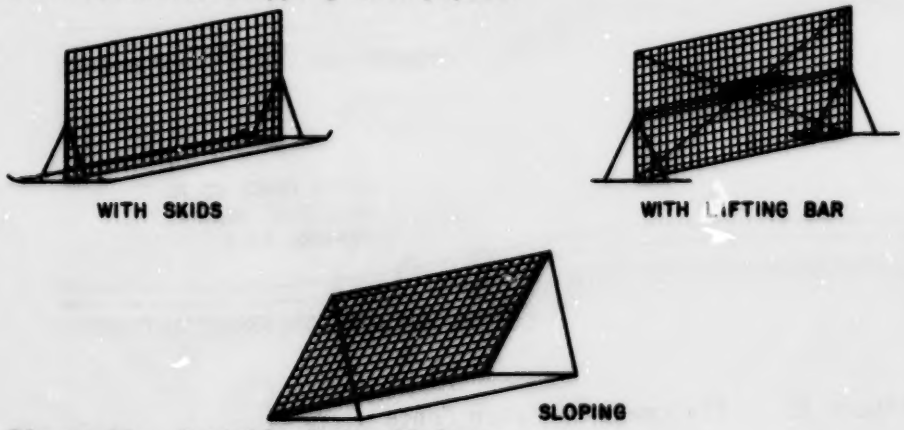

Figure 11. Portable Fence Styles

Sloping fences tend to drop papers that are stopped. The vertical fences can plug up if not maintained and can be blown over. This does not mean that sloping fences do not have to be maintained. Indeed they do!

CHAPTER 5

WINDBREAKS

It has been said that if the wind could be stopped, the landfill operator would no longer have blowing litter problems. Stopping the wind is a formidable task, but by using well placed wind breaks, either natural (i.e. trees, shrubs) or artificial (i.e. snow fence), the wind's force can be reduced.

Windbreak Theory

The main effect of a windbreak is the reduction of wind speed. The permeability of the windbreak is the major factor affecting windspeed reduction on the leeward (downwind) side of the shelter. Very dense or solid windbreaks create immediate reduction in the windspeed but also create turbulence. (See Figure 2 page 6.) Permeable windbreaks slow the wind but allow the passage of air and thus prevent turbulence.

The amount by which the windspeed is reduced depends upon the degree of permeability of the windbreak. Generally, the smaller the openings, the greater the windspeed reduction. However, the length of the protected area from the windbreak becomes shorter with the smaller openings.

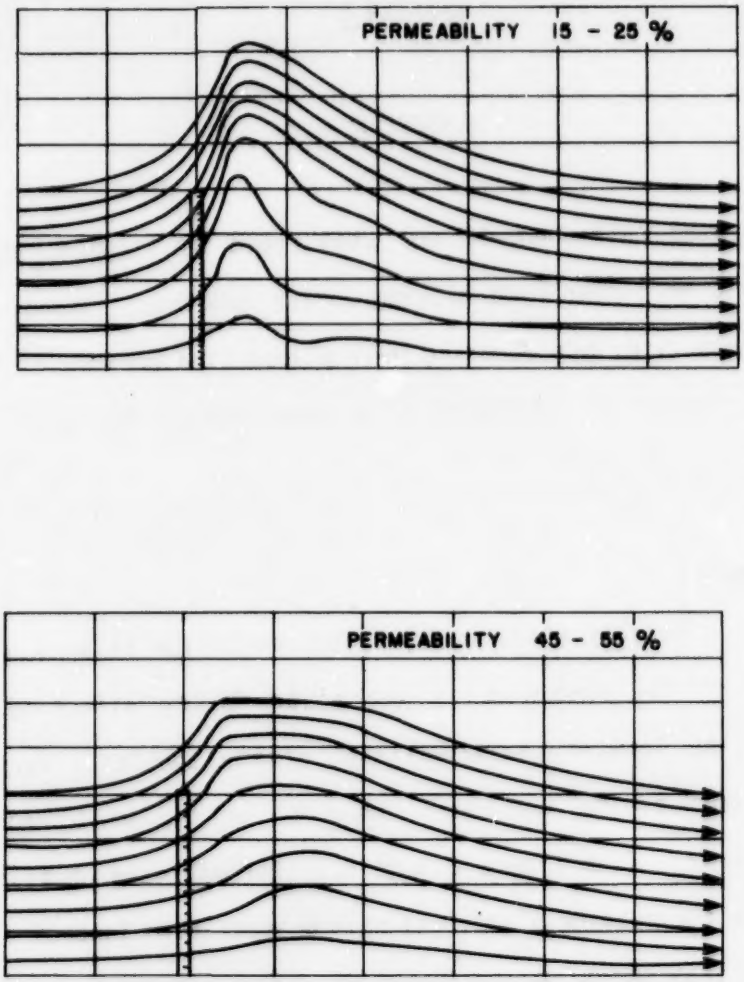

Figure 12. Effects of Windbreak Permeability

Note: Wind speed is indicated by the spacing of lines. Narrow spacing indicates higher wind speeds.

Although the 15 - 25% permeable windbreak will give a greater windspeed reduction, it does not provide the greatest area of shelter.

With a permeability of 45 - 55%, the protected area extends a distance of 4 to 6 times the height of the windbreak. (I.e. a 10-foot high windbreak would shelter an area 40 feet to 60 feet from the windbreak.) Forty-five to 55% permeability has been found to provide the optimum protection for most applications. Figure 13 shows this relationship of permeability and height of the windbreak to windspeed reduction and the distance protected downwind.

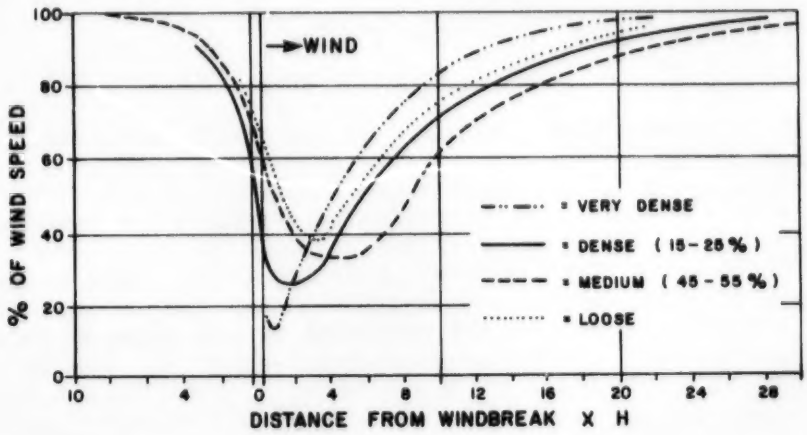

Figure 13. Wind Speed Reduction By Different Windbreaks (from investigations on wind conditions in the range of shelterbelts by W. Naegeli, 1946)

Because of other factors influencing wind speed reduction, such as ground surface roughness, the optimum windbreak permeability can vary.

Example:

The chart in Figure 12 may be used to determine the effectiveness of a windbreak. The following example explains:

Permeability	50%
Height of windbreak	10 feet
Windspeed	50 mph

Windspeed reduced to 30%
50 mph X .30 = 15 mph

Effected distance
from low peak of graph, effective area is 6 X h. (h being windbreak height)
6 X 10 - 60 ft.

Types of Windbreaks

Natural windbreaks can be extremely effective in reducing wind over the entire sanitary landfill site. Existing trees should be maintained as long as possible. Those on the perimeter of the property should be left standing as they not only provide a windshelter but also a visual shelter.

Figure 14. Natural Windbreak

If a site does not have natural tree growth, planting should be done at the very early stages of landfill development. Planting should consist of a row of tall growing trees, such as poplar, combined with second or

third rows of shorter growing trees, such as pines and caraganas. Because deciduous trees provide little protection in winter months, the evergreen trees act as a back-up during those months.

It should be noted that in some locations, trees or certain types of trees may not grow readily. This must be considered in planning tree lines.

Artificial windbreaks are very effective in the immediate working area of a landfill. Snow fences placed upwind of the working face or along the edges of trenches are a good option.

If the wind direction is constant, semi-permanent fences can be constructed along a trench length (see Figure 9, page 12). Portable fences, which can be moved according to wind direction or moved as the working face moves, can be constructed. With portable fencing, trench direction can be either perpendicular to or parallel with the wind direction. Figures 15 & 16 show how such fences may be used.

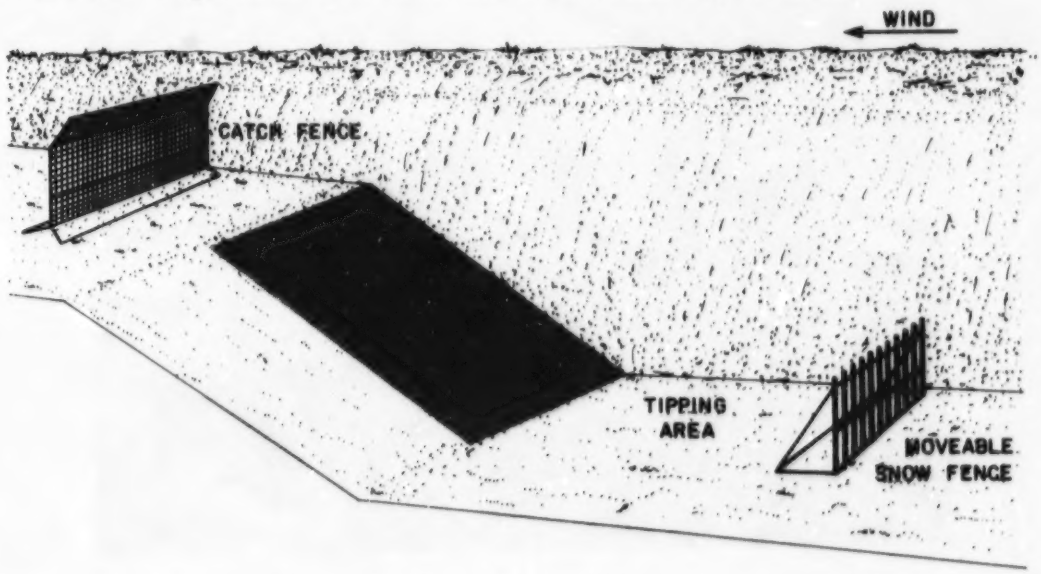

Figure 15. Fencing for Funnelling Wind

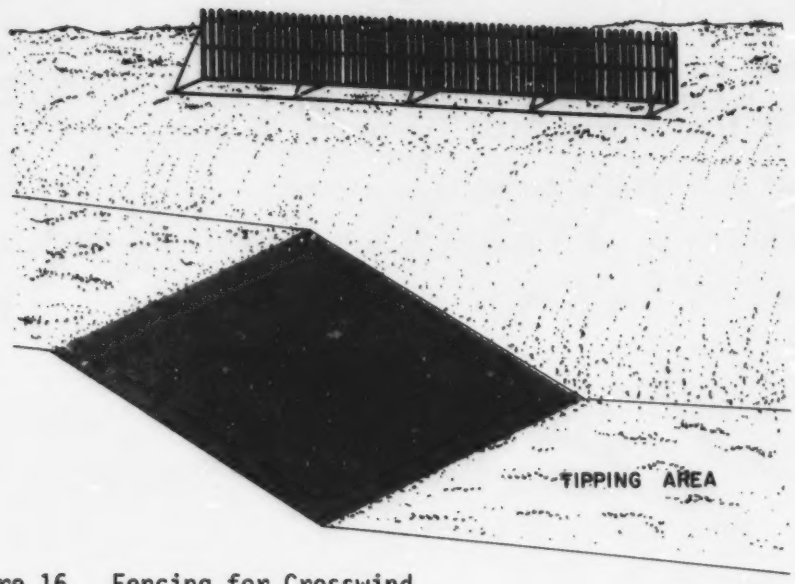

Figure 16. Fencing for Crosswind

Snow fencing can be purchased in rolls and erected as semi-permanent fencing. Portable fencing can be constructed from snow fencing or lumber slats mounted on skids. It must be remembered that the higher the fence, the larger the base that is required.

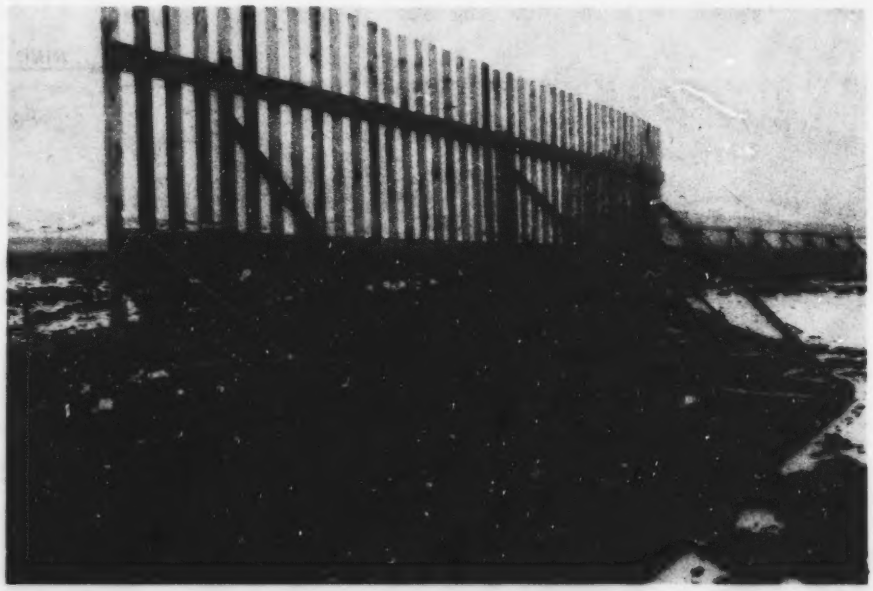

Figure 17. 10 Ft. (3m) Portable Windbreak

Snow may build up in the shelter of windbreaks. Snow build-up behind fencing can be removed easily with landfill equipment. As well, snow build-up can be lessened by constructing smaller secondary fences upwind of the primary windbreak to catch the drifting snow.

CHAPTER 6

SITE-USER CONTROLS

Controlling blowing litter is not entirely the responsibility of the landfill operator. Site-user practices can be very important in keeping the problem under control.

Uncovered refuse in the haulage vehicle is susceptible to being blown about roadways leading to the landfill. All wastes must be secured or covered by tarps. Enforcement of by-laws is required to insure that loads are covered.

Wastes that are packaged in bags or boxes are less prone to blowing. Many communities have by-laws regarding the packaging of wastes in plastic bags to maintain clean storage and ease of collection. Even where such by-laws do not exist, many urban residents bag wastes. Rural residents and commercial establishments are less likely to bag waste because of the difference in collection and storage methods. These consumers should be encouraged to package their waste.

Vehicles should be unloaded in sheltered areas. If windbreaks are not used, unloading should be done below ground level in an area where there is no air movement. In light winds (less than 15 mph.[24km/h]), it can be advantageous to unload vehicles with their rear facing the wind. This tends to hold the loose papers in the main load.

CHAPTER 7

PROCESSING WASTES TO REDUCE BLOWING LITTER

"Processing waste" refers to methods used to change the waste characteristics. Two methods of changing the characteristics are shredding and baling. With a shredding process, wastes are ground into small particles. Baling is the compressing of wastes into a bale form so that it may be bound with wire.

Both these processing methods are used primarily to reduce volume or reduce transportation costs. They are also considered to be of use in controlling blowing litter. The mechanical processing of the wastes is accomplished inside a building in which collection vehicles are unloaded, so there is no wind-blown debris upon dumping.

It has been found that shredded waste produces far less blowing litter than normal unshredded wastes. This is because the particles tend to be intertwined and discharged as a mass. Also, the surface area of the particles is less than that of paper sheets and is not carried as easily by the wind. Shredded refuse has been observed blowing only a few feet upon being dumped in a strong wind.

There are exceptions to this rule, however. In an actual case, dry office paper was shredded in a large institution. These shredded papers were seen blowing upon dumping, and bagging of the shredded paper was required.

Wastes that are compressed into a bale are not blown because the papers and plastics are intermingled into the mass. Baling wastes has been suggested in some areas specifically for this purpose.

Processing of municipal wastes adds to the overall expense of waste disposal unless cost savings in transportation and land requirements are provided. For small communities, the cost may be prohibitive. Small processing equipment, used by commercial establishments or private institutions, can aid to some degree in controlling litter.

CHAPTER 8

CASE HISTORY

(Crowsnest Pass - Pincher Creek Regional Sanitary Landfill)

The Regional Sanitary Landfill serving the M.D. of Pincher Creek and the Municipality of Crowsnest Pass is located near the village of Cowley in Southwestern Alberta. The landfill is situated on a plain just east of the Rocky Mountains. The region is the recipient of strong Chinook winds that funnel through the Crowsnest Pass. These westerly winds have an average annual speed of 17 mph (kmph). Wind speeds have been recorded at 85 mph (130 kmph) with gusts of up to 115 mph (240 kmph).

Because the Chinook conditions in the winter cause rapid thawing and freezing, tree growth is very sparse. The landfill property and surrounding area have no natural tree growth, and growing trees for shelter has not been successful.

The landfill operators experimented with a variety of wind controls, but depended upon downwind fencing to catch wind-blown litter. Because of the amount of work required to pick up papers (one to two days per week), controlling the force of the wind became extremely important.

Trenches were excavated from north to south. Originally, the soil stockpiles were intended to block the wind but the turbulence that resulted created additional problems. With the upwind stockpile removed, the operators experimented with a solid fence constructed of discarded tires

built to a height of about 5 feet (1.5 m). The tire wall extended the length of the trench. Again, the turbulence that formed created problems.

A portable slatted fence was constructed and placed along the west side of the trench in the immediate area of the working face. The fence is constructed of 1" X 6" (25 mm X 150 mm) boards spaced with a 50% opening. The height is 12 feet (36 m). The base is constructed of discarded oil well drill casings and other such piping.

With the first sections in place, it was found that, even with extreme winds, the air was calm at the working face. Other sections were constructed to protect the working face from the southwest as well as the west.

The success of the fence is measured by the fact that far less litter is windblown, which resulted in reducing labour to about 1/10 of the time previously spent picking up the litter.

Figure 18. Original Spoil Pile Method

Figure 19. Artificial Windbreak in Place

CONCLUSIONS

The landfill designer or operator must decide if it is more practical to catch wind-blown debris or shelter the working face. If winds are constant in direction, a shelter can be easy to install. If the wind direction is inconsistent, catching the papers may be more practical. By combining both control methods, the maximum positive results can be achieved.

The operator should learn to watch the wind patterns that develop on his site. Using a little ingenuity, he will be able to take advantage of those patterns. He may be able to develop the site to form desired patterns.

Landfill administrations must consider labour saving costs as well as capital expenditures. Spending money to construct windbreaks and catchfences can save money and time.

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